Vertical distribution of stratus cloud properties derived from both ARM and CERES-MODIS observations

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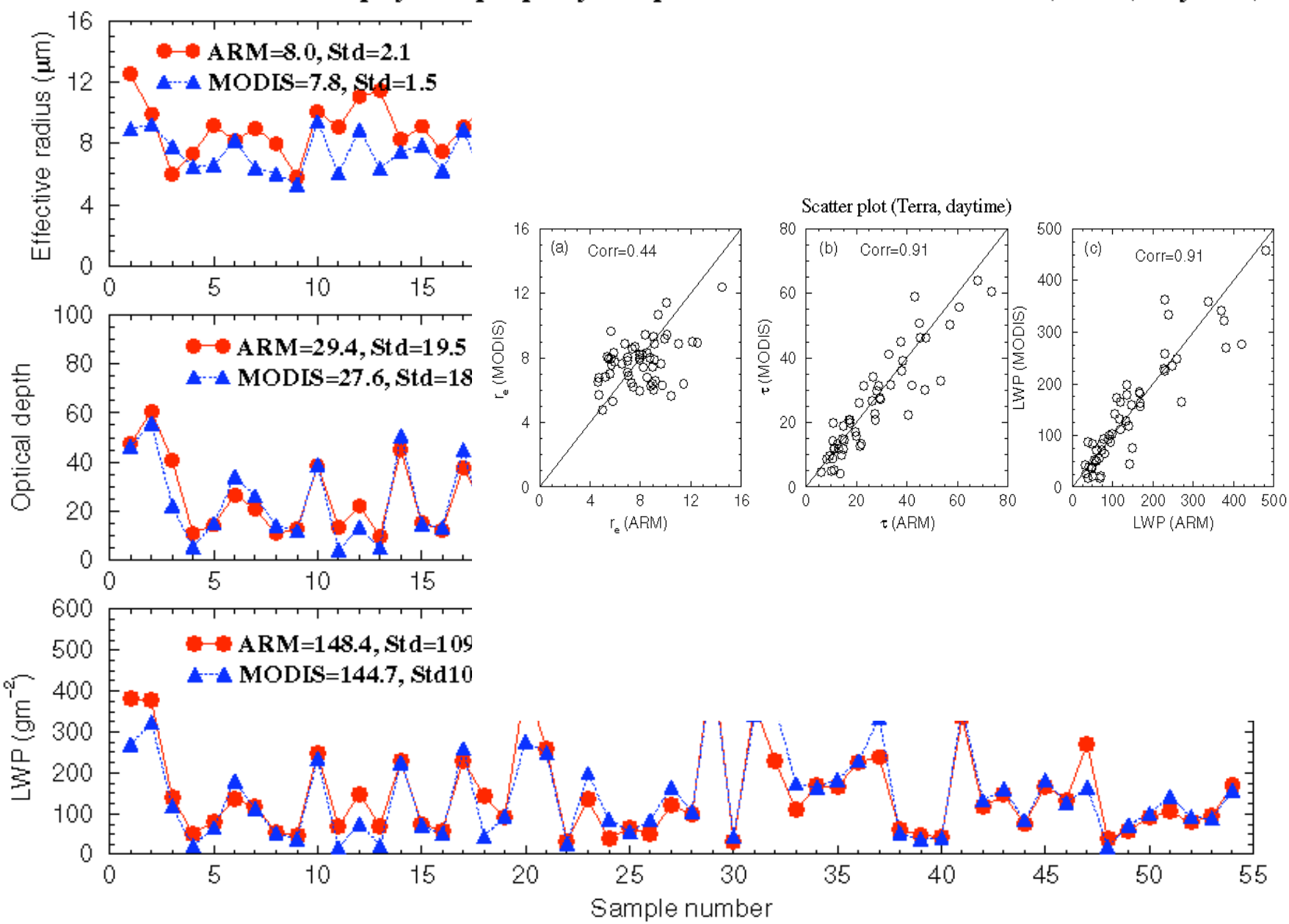


Dong et al. 2007, JGR

Objectives

1. To compare the CERES-MODIS 3.7-um and 2.1-um retrievals with ARM radar/lidar retrievals at SGP site
2. To study how vertical distributions of stratus cloud properties associate with surface moisture

Based on ARM retrievals and observations, we define the following four categories:

1. LWC/re increase linearly with height, coupled with strong surface moisture.
2. LWC/re are nearly constant with height, coupled with surface moisture, but this moisture is capped by temp. inversion layer.
3. LWC/re decrease with height under dry condition.
4. LWC/re decrease with height with drizzle near cloud base

Stratus Cloud Properties

- **Liquid Water Content**
  - **Average LWC increases with height**
  - **Generally less than adiabatic**
  - **Undiluted adiabatic pockets**
  - **Mixing**

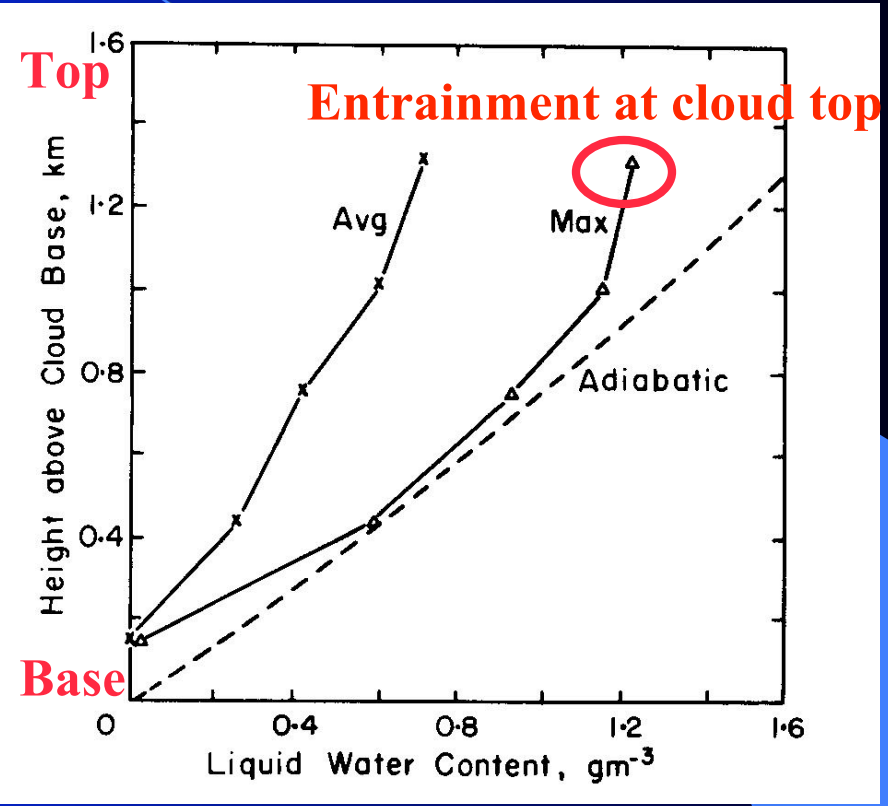
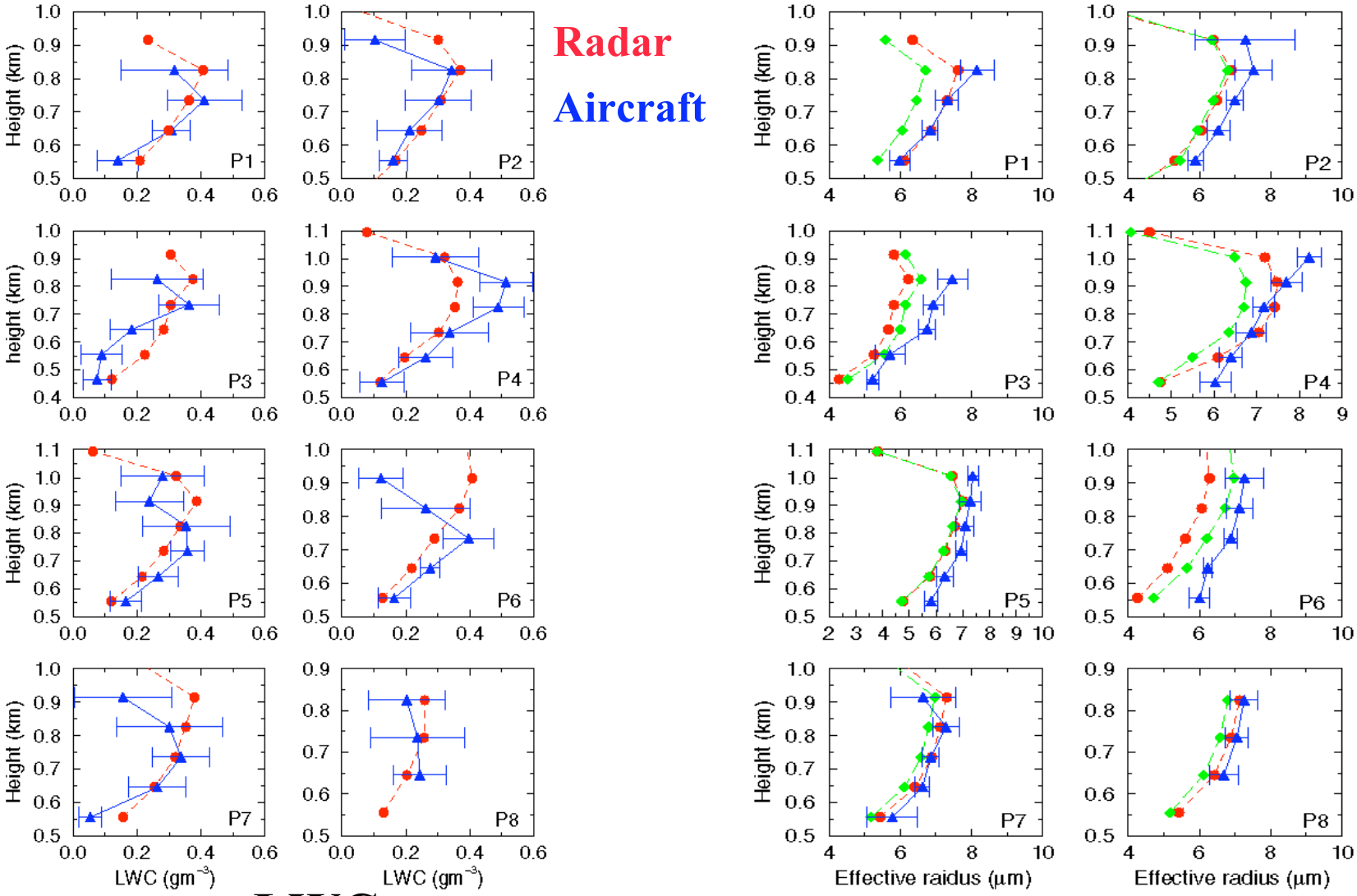


Fig. 5.6 of Rogers and Rau

LWC and re derived from ARM radar and observed by Aircraft (3/3/2000)

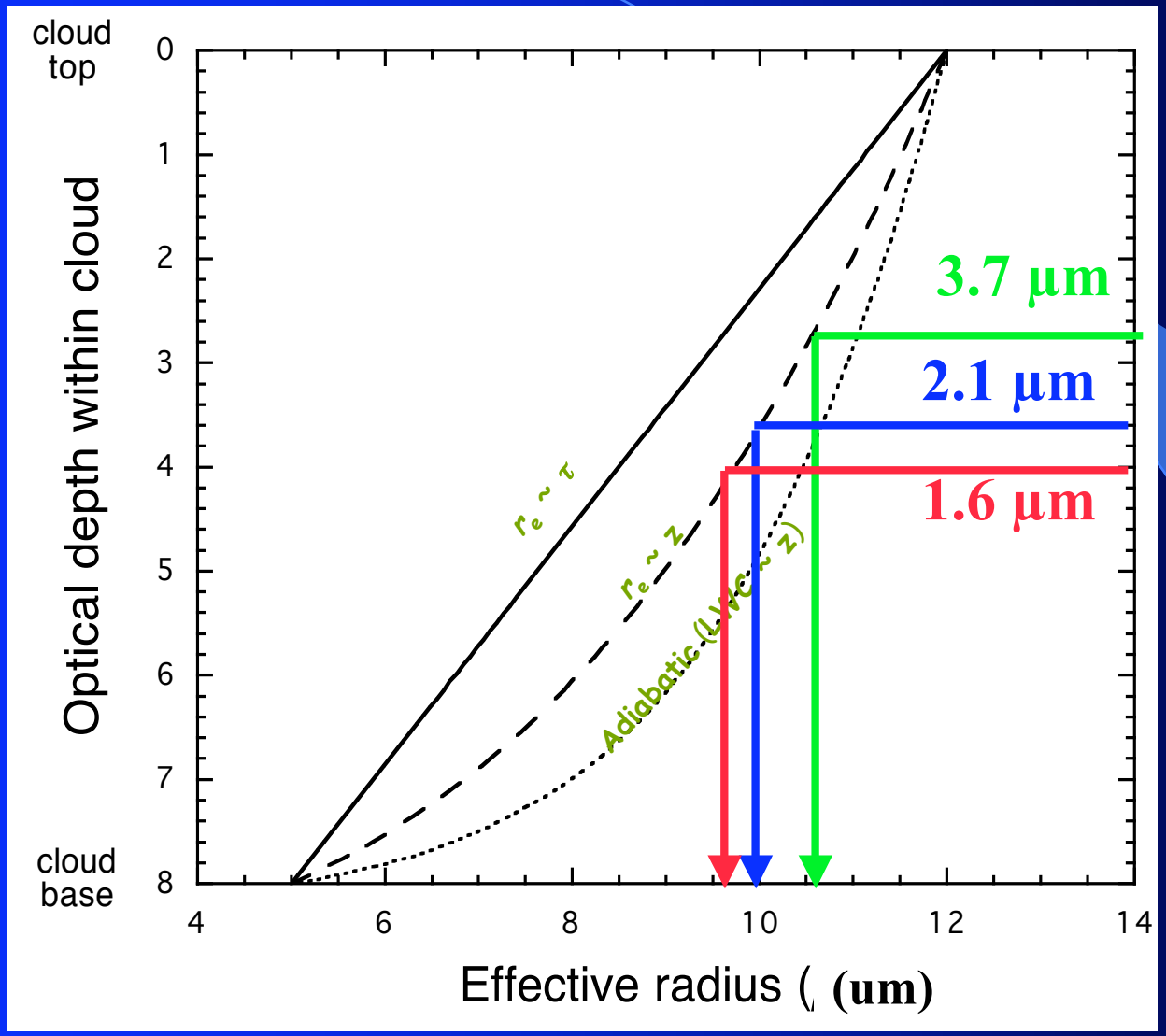


LWC

Dong et al. 2003, JAM

re

Effective radius (re) retrieval differences in 1.6-um, 2.1-um, and 3.7-um channels (theoretical)



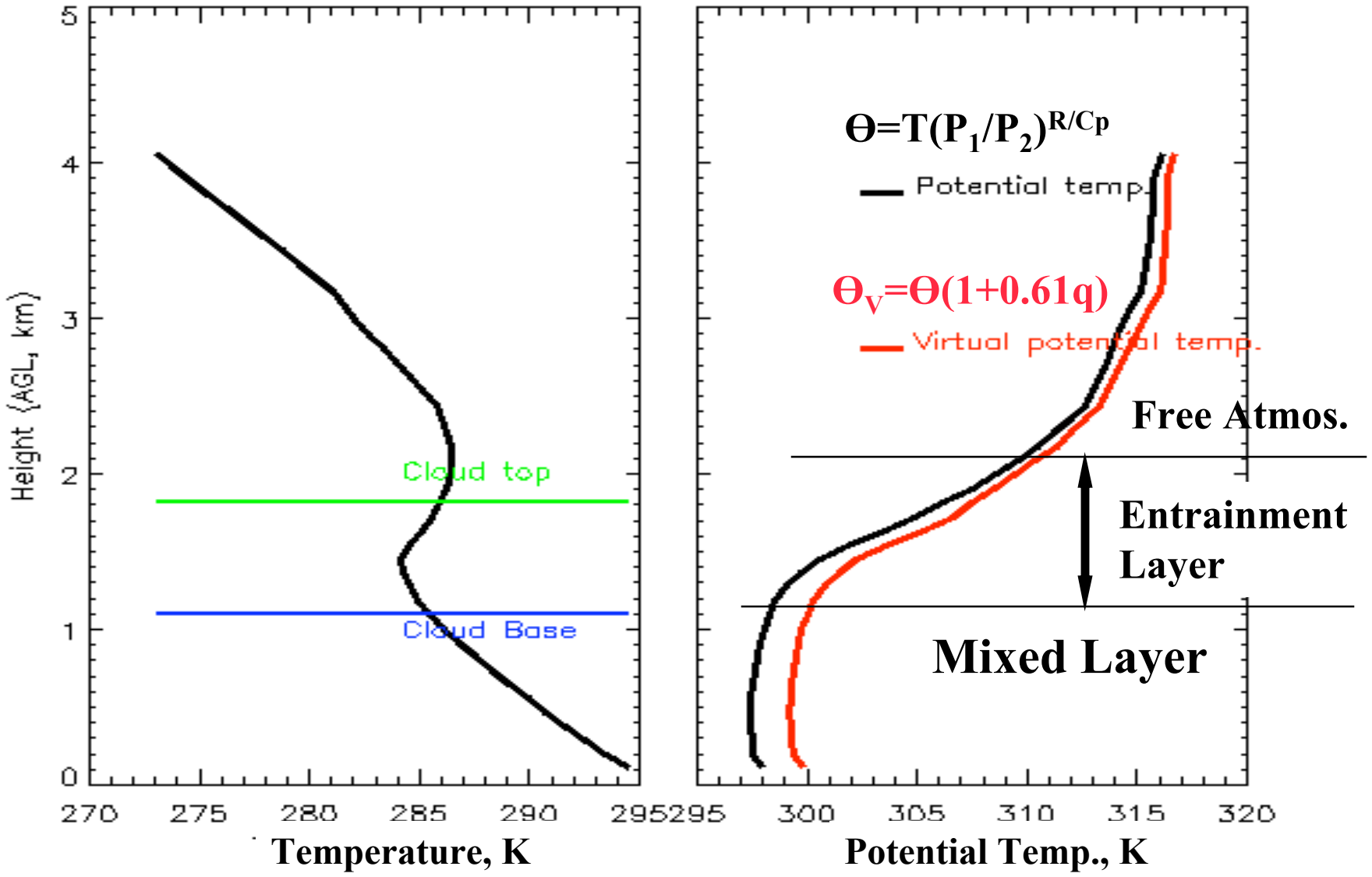
Courtesy of Platnick, ISSAOS '02

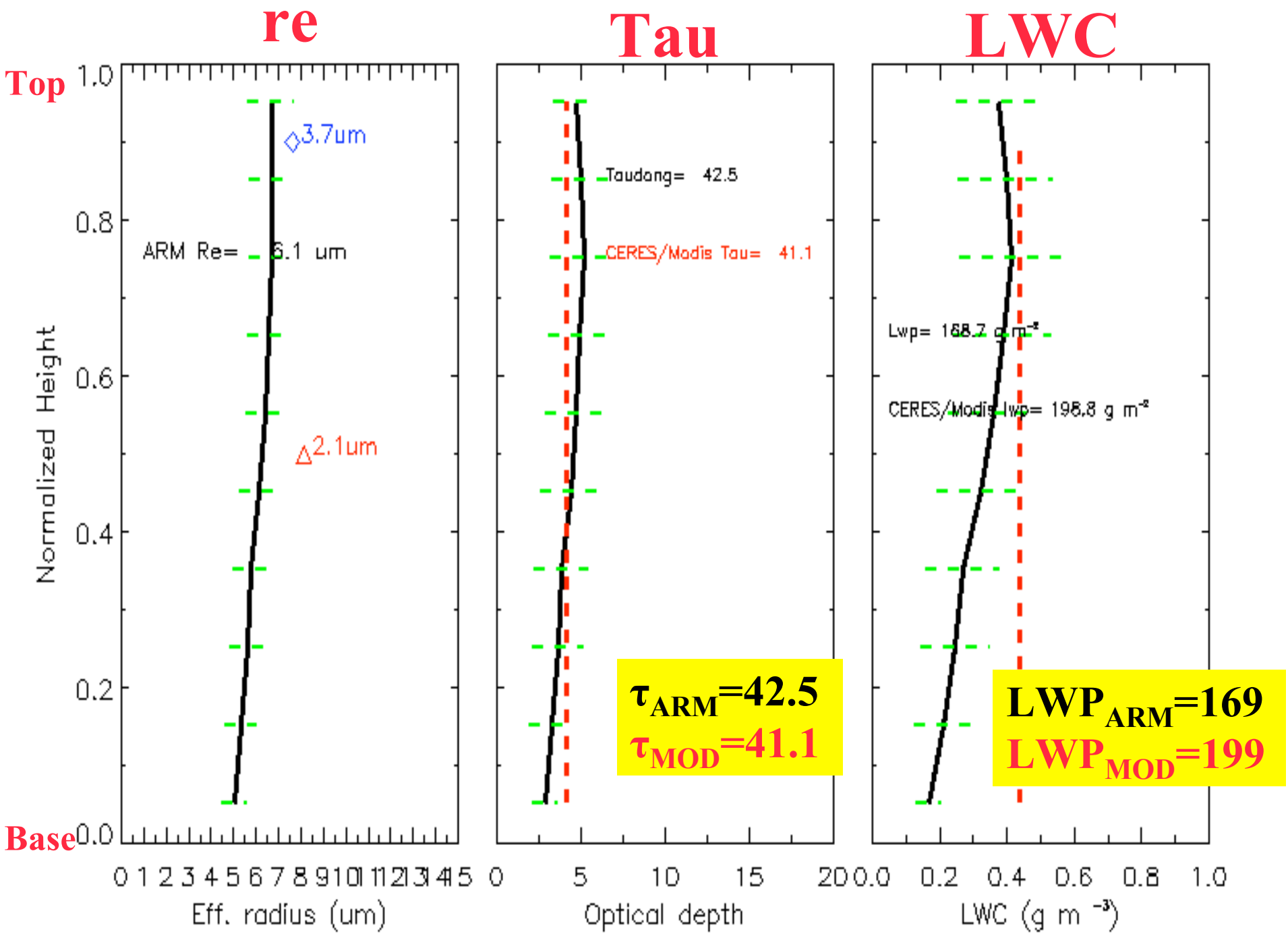
Category 1:

LWC/re increase with cloud height, coupled with strong surface moisture

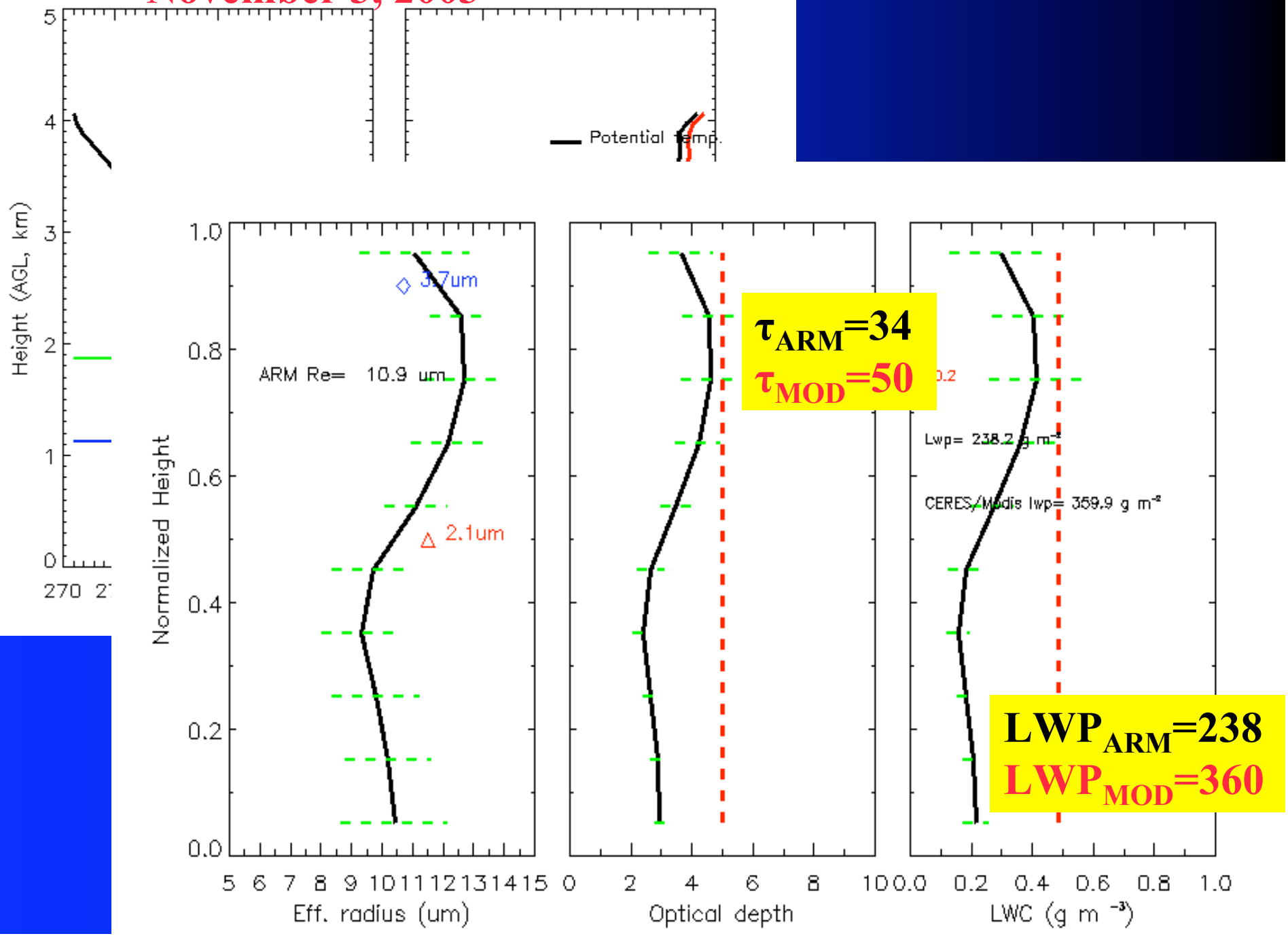
The large difference of (Θ_V- Θ), the more surface moisture

May 22, 2002




re
Tau
LWC
Top
Base
Normalized Height
1.0
0.8
0.6
0.4
0.2
0.0
◇3.7um
△2.1um
ARM Re= 6.1 um
Taudong= 42.5
CERES/Modis Tau= 41.1
Lwp= 168.7 g m⁻²
CERES/Modis lwp= 198.8 g m⁻²
τARM=42.5
τMOD=41.1
LWPARM=169
LWPMOD=199
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Eff. radius (um)
0 5 10 15 20
Optical depth
0.0 0.2 0.4 0.6 0.8 1.0
LWC (g m⁻³)

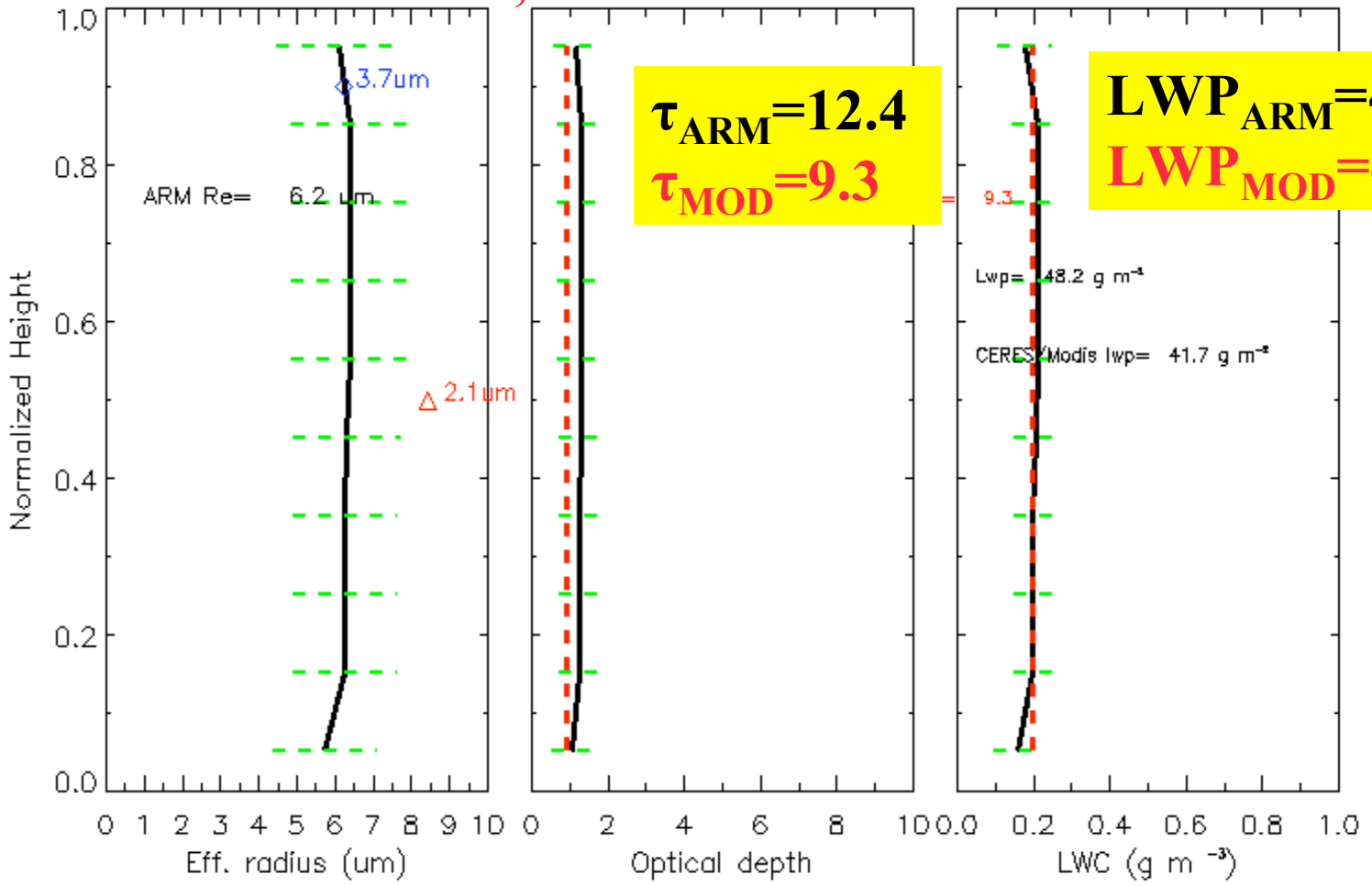
November 3, 2003



Category 2:

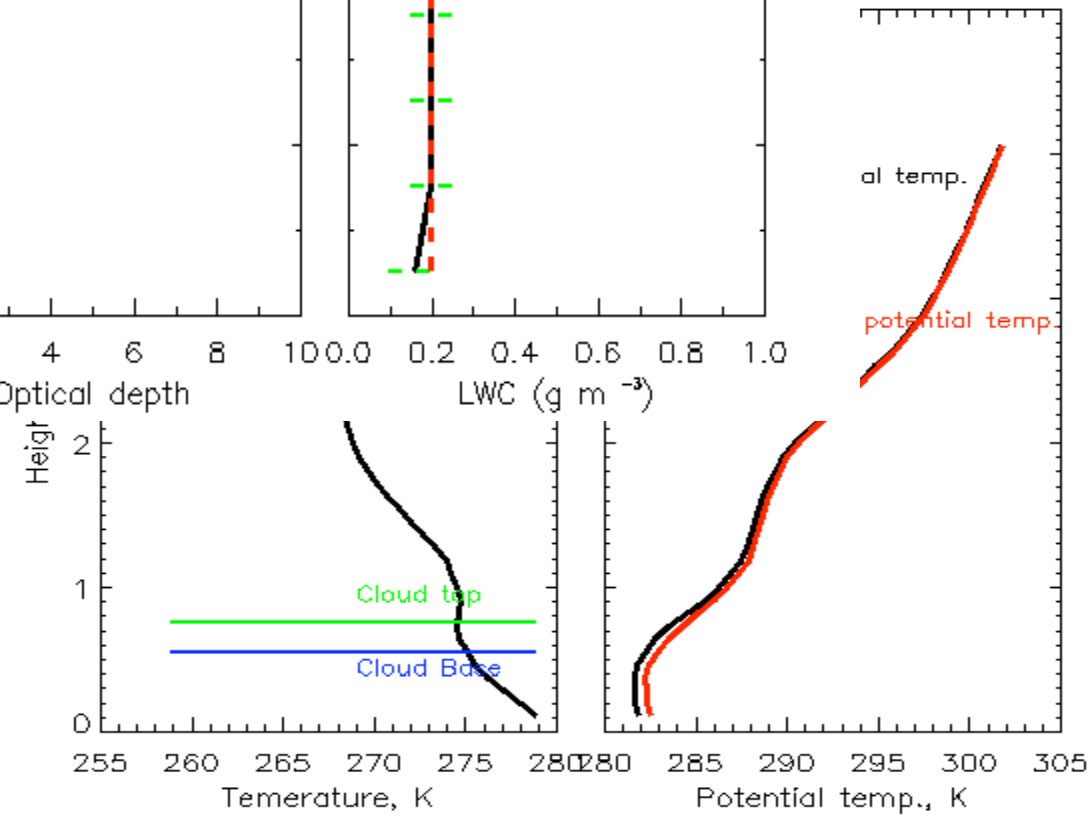
LWC/re are nearly constant with height, coupled with surface moisture, but this moisture is capped by temp. inversion layer

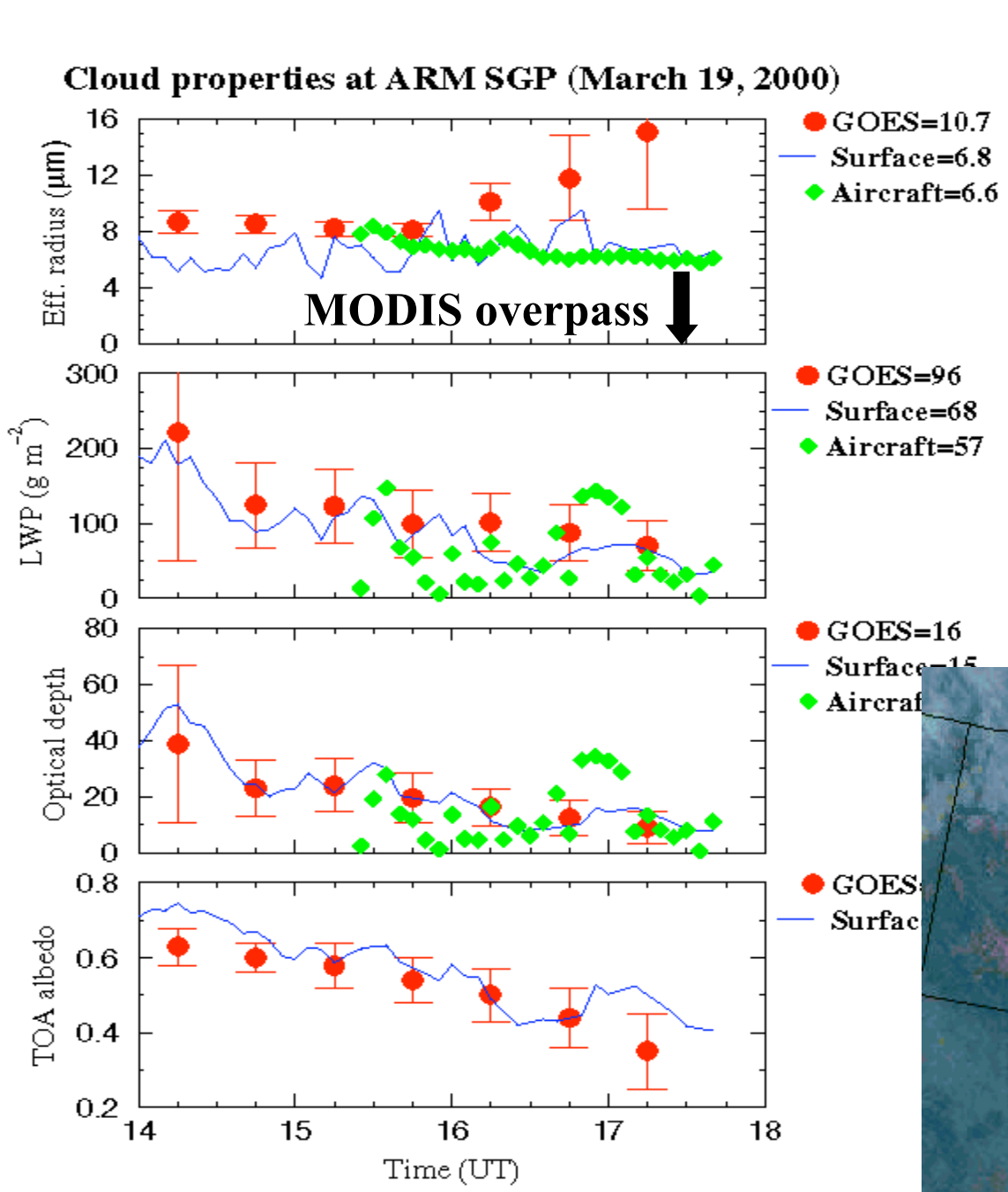
March 19, 2000 at ARM SGP

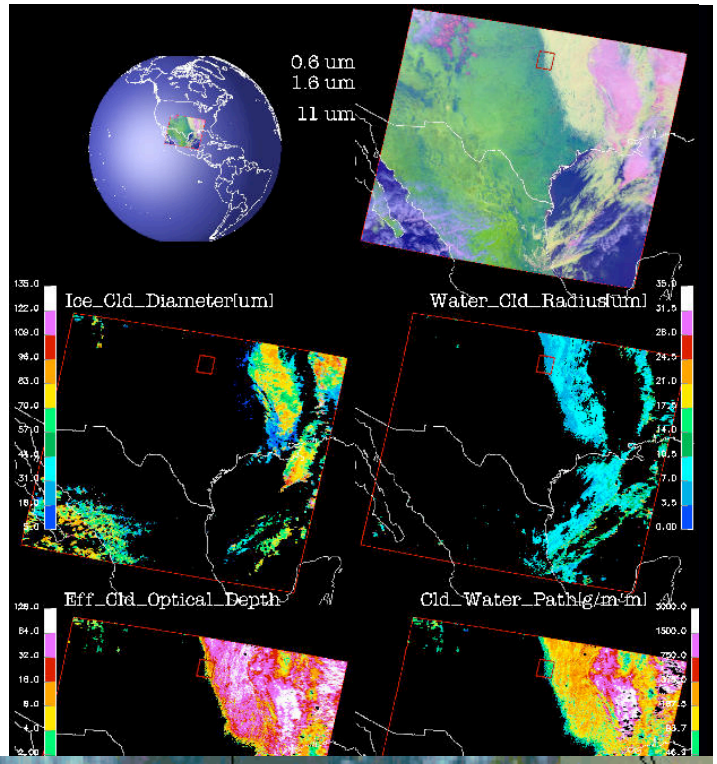


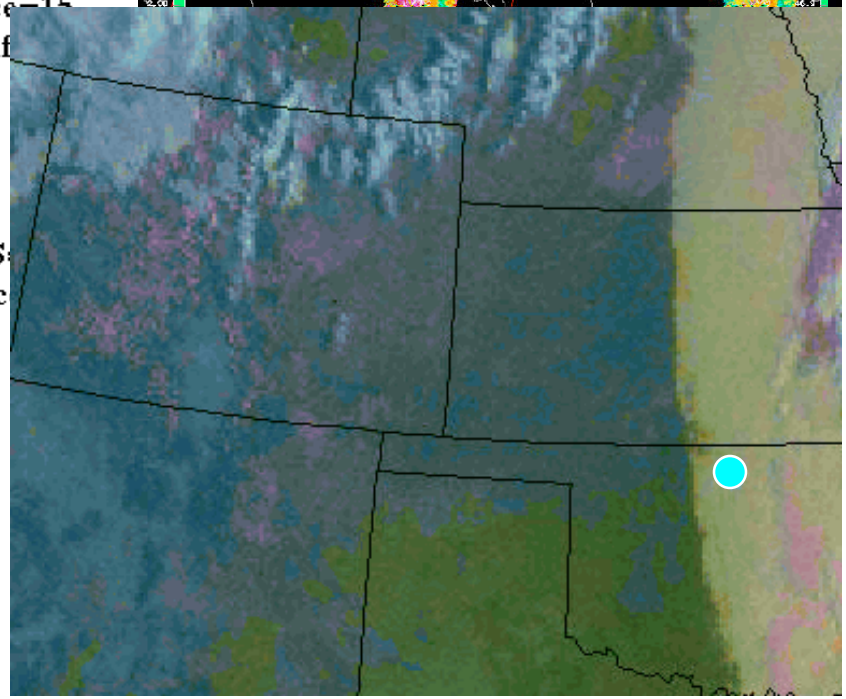
τ_{ARM}=12.4
τ_{MOD}=9.3

LWP_{ARM}=48
LWP_{MOD}=42



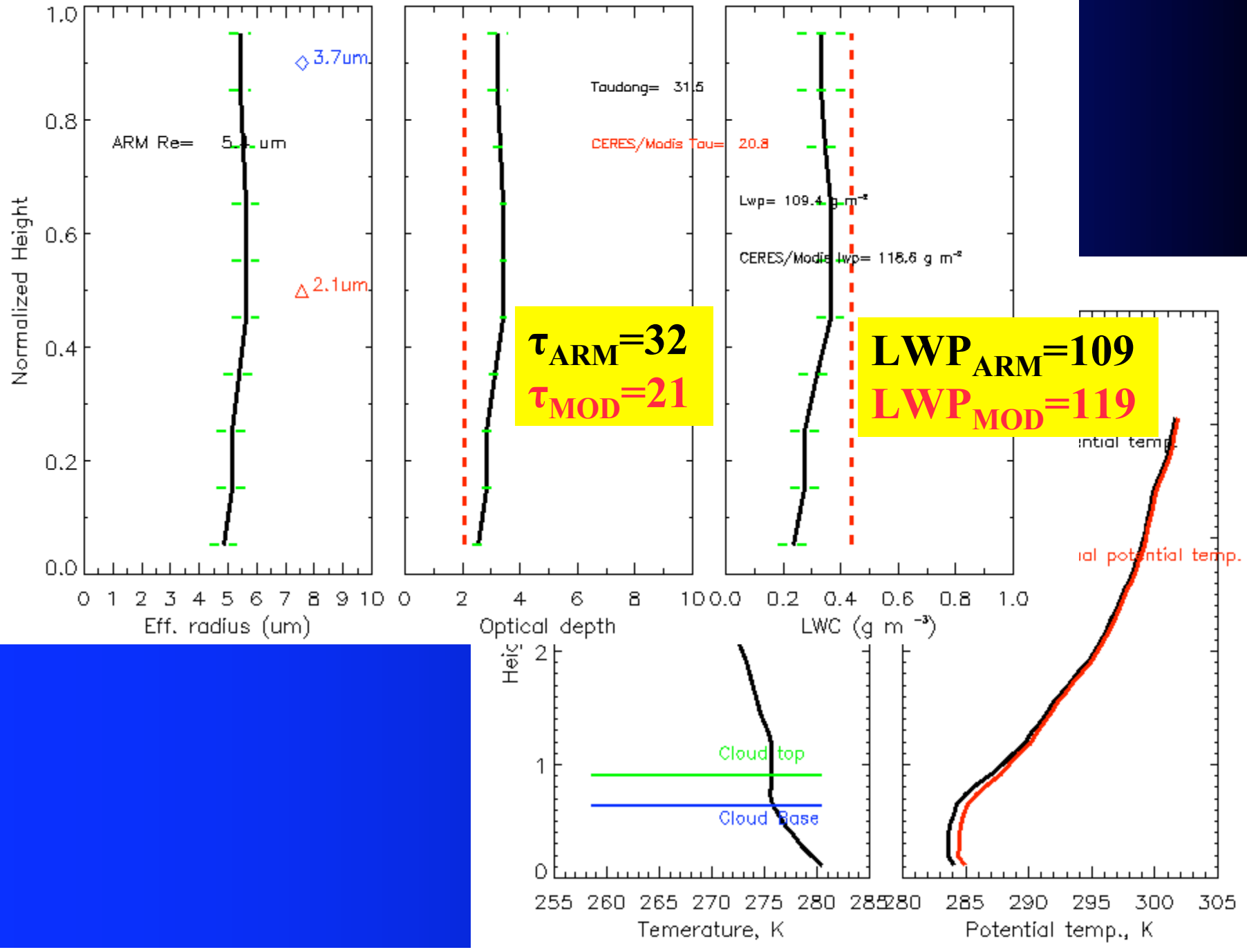






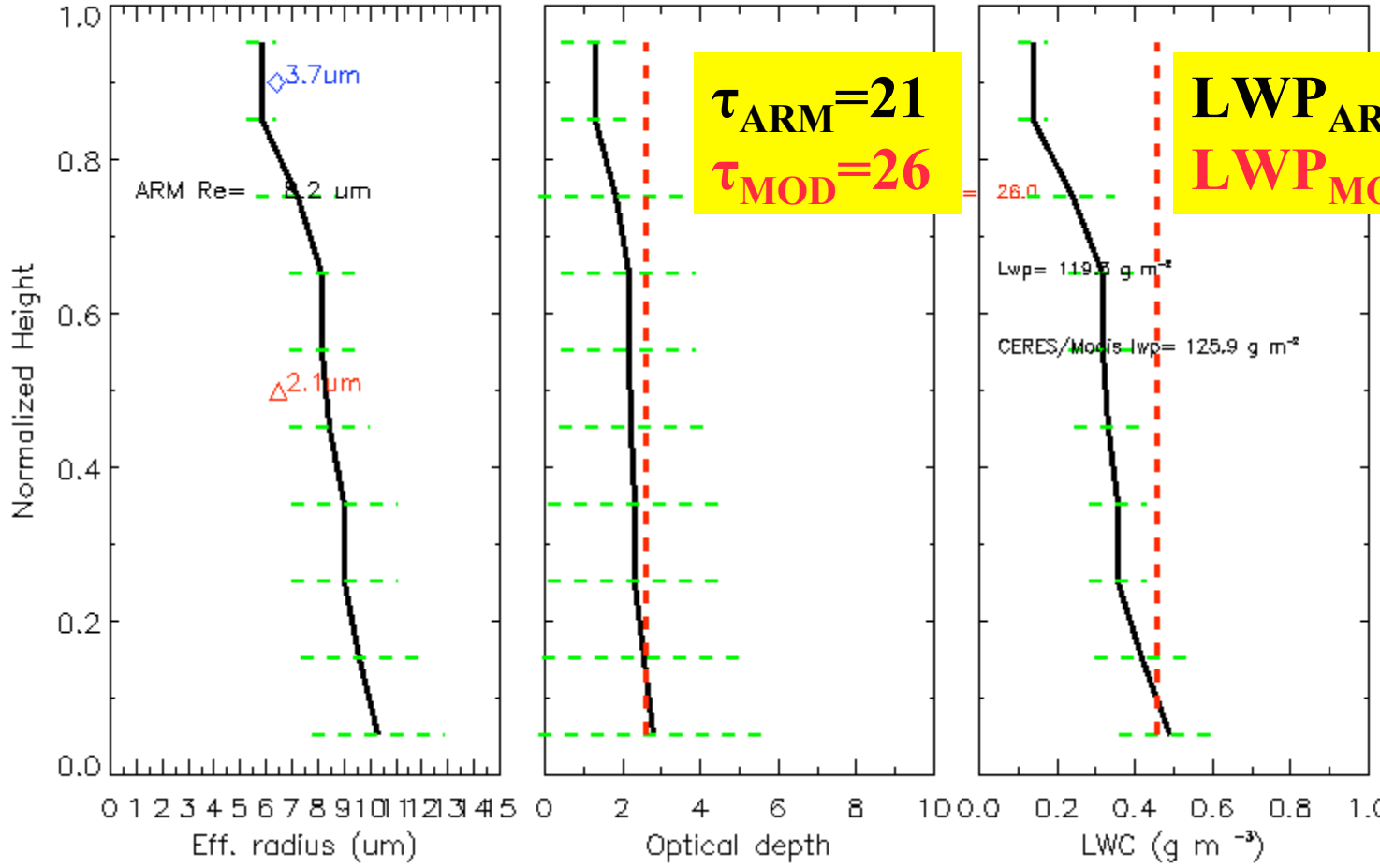
Dong et al. 2002, JAS

November 05, 2002



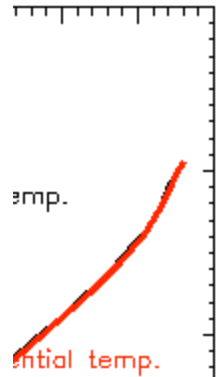
Category 3:

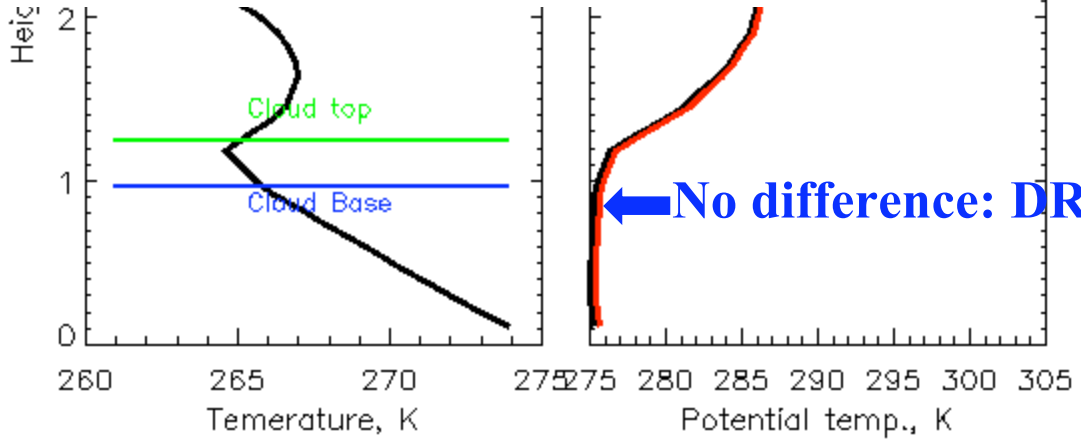
LWC/re decrease with height, under relatively dry condition.



τ_{ARM}=21
τ_{MOD}=26

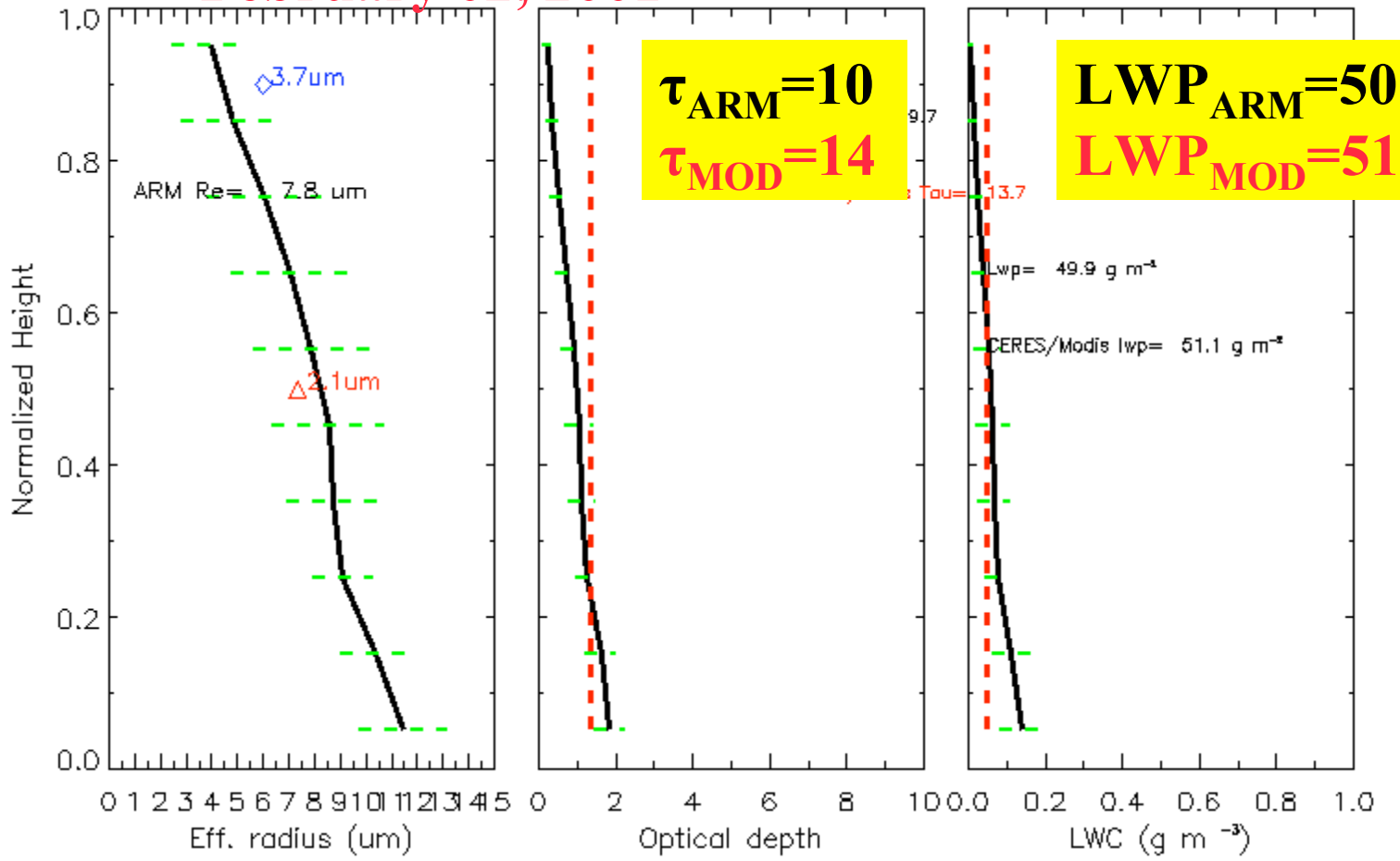
LWP_{ARM}=119
LWP_{MOD}=126





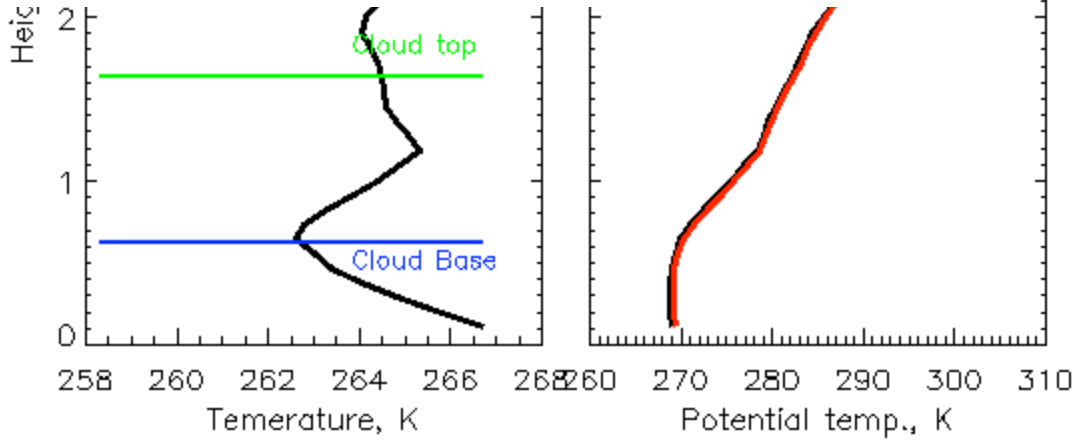
No difference: DRY

February 02, 2001



τ_{ARM}=10
τ_{MOD}=14

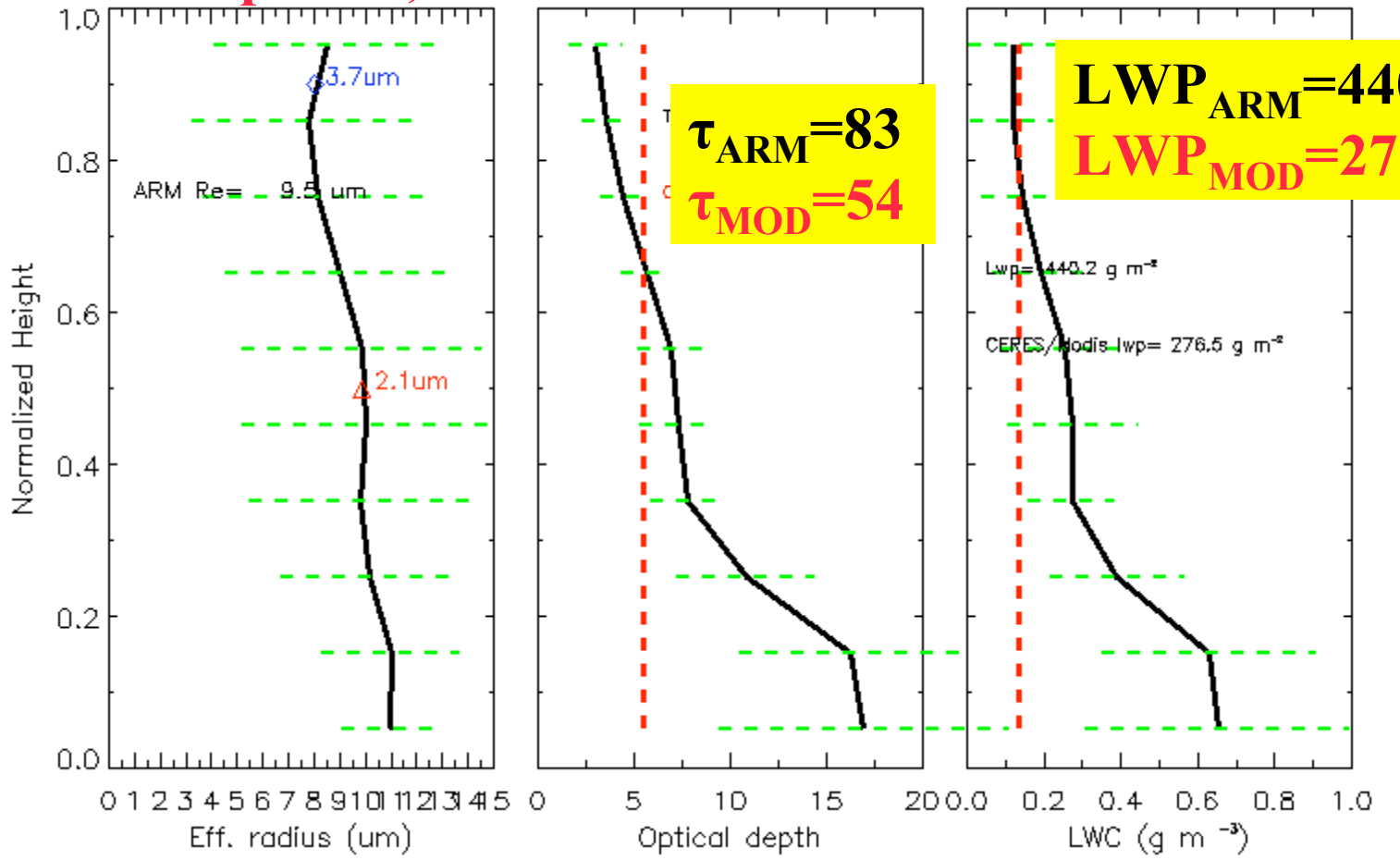
LWP_{ARM}=50
LWP_{MOD}=51



Category 4:

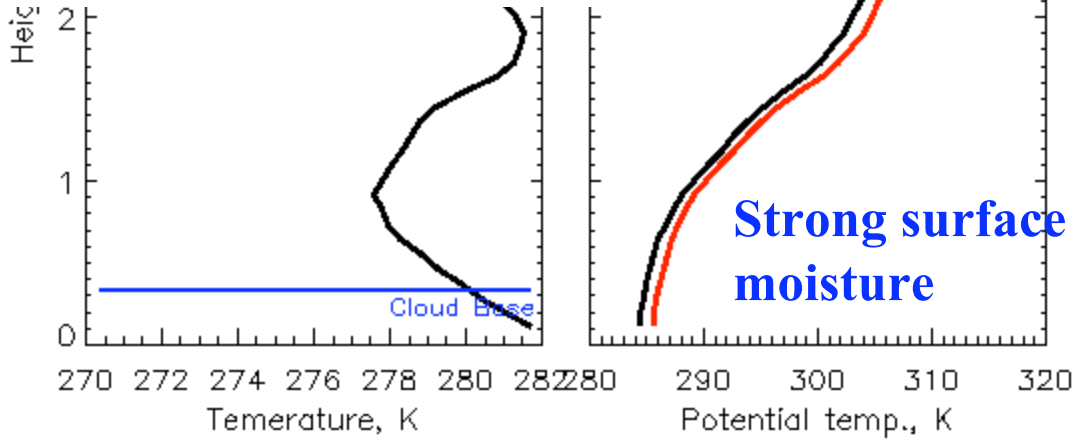
LWC/re decrease with height with drizzle near cloud base

April 26, 2002

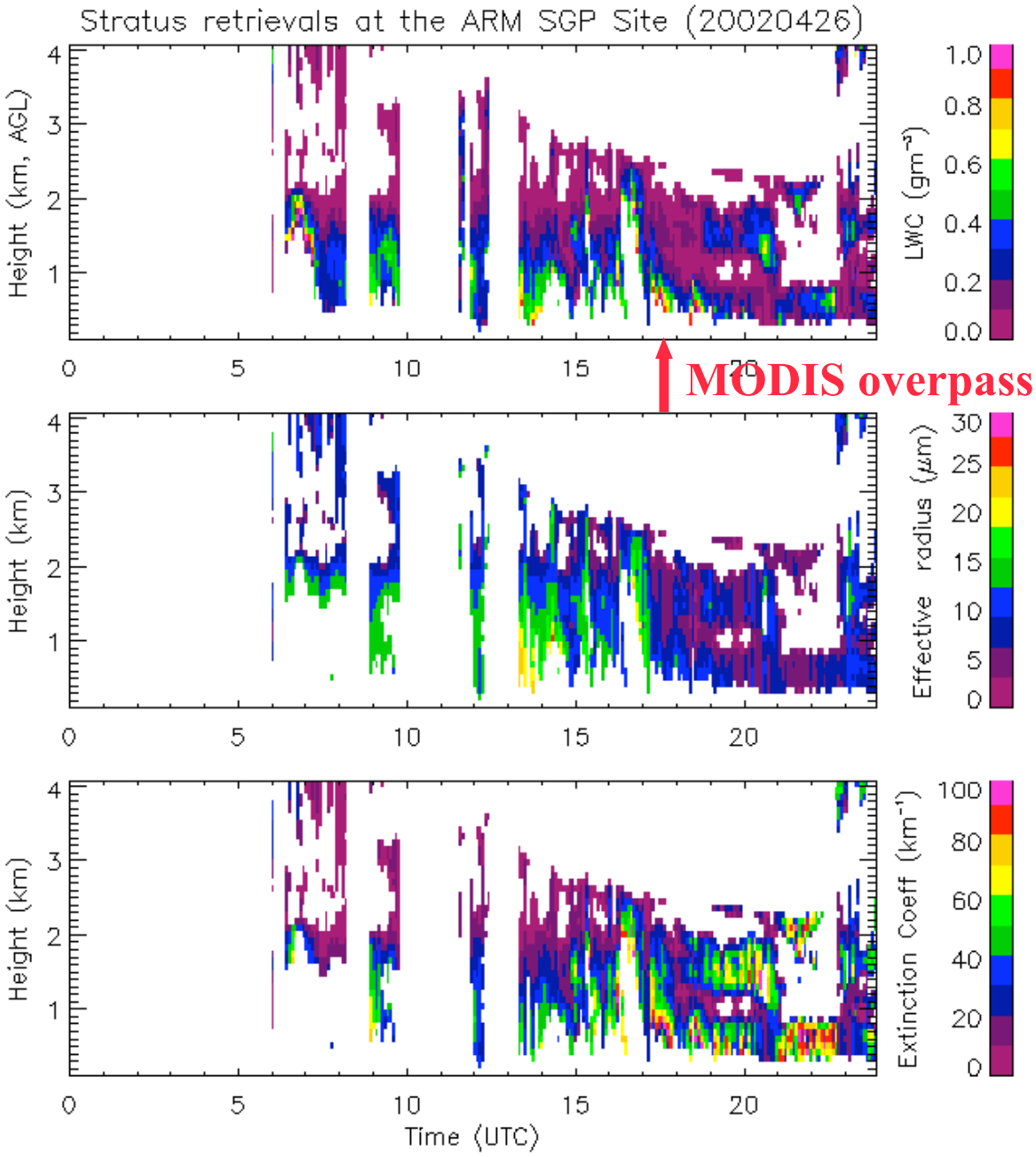


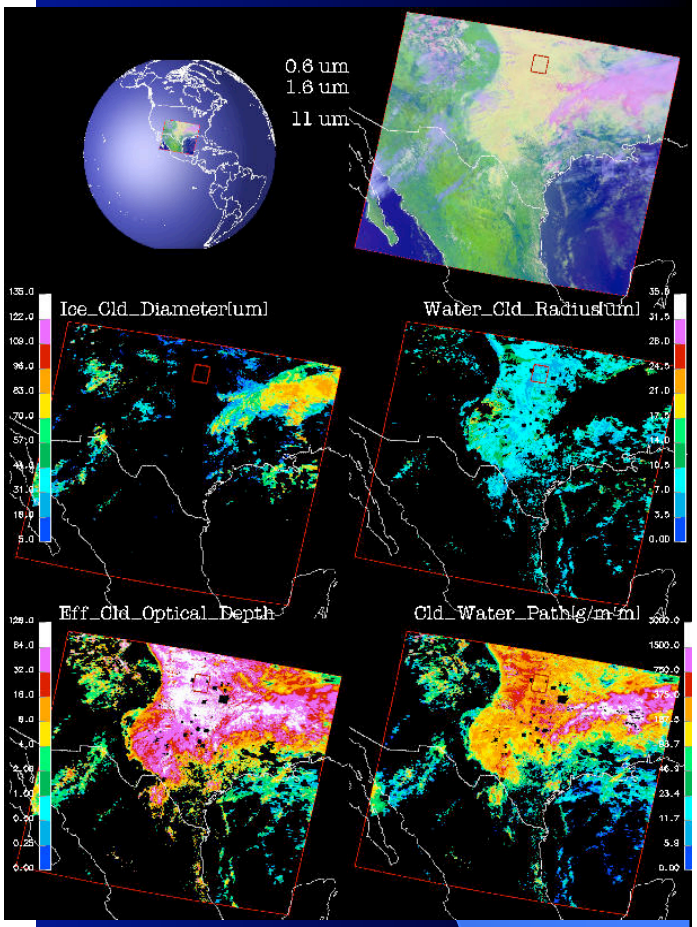
τ_{ARM}=83
τ_{MOD}=54

LWP_{ARM}=440
LWP_{MOD}=277



Strong surface moisture


Stratus retrievals at the ARM SGP Site (20020426)
Height (km, AGL)
LWC (gm⁻³)
Height (km)
Effective radius (μm)
Extinction Coeff (km⁻¹)
Time (UTC)
MODIS overpass


0.6 um
1.6 um
11 um
Ice_Cld_Diameter[um]
Water_Cld_Radius[um]
Eff_Cld_Optical_Depth
Cld_Water_Path[g/m^2]

Summary

1. In general, the 3.7-um retrievals agree with ARM retrievals better than the 2.1-um retrievals.

2. Nearly all 2.1-um retrievals are larger than the 3.7-um retrievals, and consistent with the ARM retrievals in Categories 3 and 4, but not in Categories 1 and 2. Therefore a further study is needed.

3. Without Drizzle near cloud base:
With more surface moisture, LWC/re increase with height. Under dry condition, LWC/re decrease with height.